Giving value to wastes

Development of new technological routes to waste management

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CVR – Centro para a Valorização de Resíduos (1) is a non-profit private organization created in 2002, to contribute to the development of new approaches to waste management, where wastes are seen as potential resources, both as energy as well as materials.

CVR is located in Guimarães, integrated in the Campus of University of Minho. This university is the main stakeholder of CVR, along with the Industrial Association of Minho (AIMinho) and the Portuguese Foundry Association (APF). It accounts also with 60 more private companies as associates, and around 15 researchers and technicians.

The main purpose of CVR is to help industry and municipalities to introduce innovative waste management options with respect to the waste management hierarchy, and economically and environmentally feasible, and adequate to local situations. In this sense, CVR is working on several fields:

- wastes incorporation in civil construction materials;
- metals and metallic salts recovery from wastes;
- waste-to-energy operations;
- organics recovery from animal by-products;
- construction and demolition wastes recycling;
- bio-fuels and residue derived fuels;
- integrated waste management systems

In the area of incorporation of wastes in construction materials, CVR is being very active in the development of new ceramic materials containing industrial wastes, as well as on the incorporation of wastes in clinker production.

In what concerns the incorporation in ceramics, research has been done on red clay bricks (Figure 1), with the incorporation of industrial wastes like wastewater treatment sludges (from anodizing of aluminium, steel pickling or other surface

treatment and metallic coatings operations) and foundry sands and dusts. In these cases, different degrees of incorporation have been studied. Mechanical properties as well as leaching behaviour have been determined. Mechanical data on flexural and compression strength allowed determine degree of incorporation that does not affect quality of products. Leaching behaviour has been obtained by standardised method (DIN 38414-S4), to evaluate the inertization degree of some potentially hazardous components of the wastes (heavy metals, for example) to estimate environmental impact of the procedure on the bricks at the end of their life cycle (2-4). Research is being done on a laboratory scale, as well as industrial testing (projects Ecoceram, with Portuguese companies, and Ecoinert, with Portuguese, Spanish and Italian companies and other research institutions).

Figure 1 – Red clay bricks fabrication.

Incorporation in expanded clay products has also been studied with several industrial wastes, like sludges, foundry sand and dust, as well as wastes from the papermaking industry. In this case, expanded clay products (see figure 2) were tested for mechanical strength (compression) and leaching behaviour, also in laboratory as in industry. This allowed to obtain a set of degrees of incorporation that preserves quality of the product, without affecting environmental performance, when the product becomes itself a waste material. This has been studied under project Waste2Ceram.

Figure 2 – Expanded clay products containing industrial wastes.

Research on the incorporation of wastes in clinker production (Figure 3) has been studied for wastewater organic sludges, water processing sludges, wastes from papermaking and wastes from foundries. As clinker presents a chemical composition where alumina, iron oxides, potassium oxide, silica and magnesia are always present, incorporation of wastes with some of these oxides presents a good management option for these residues. Research has been done mainly at industrial scale. In this case, different proportions of wastes have been considered, with the evaluation of mechanical strength of clinker pellets and of leaching behaviour, especially in what concerns heavy metals release. This research allowed determine several types of wastes that may be incorporated in clinker production (5-6). As a consequence of these research activities, this practice is now being current in some Portuguese cement companies.

Figure 3 – Clinker production kiln.

In the incorporation of wastes in ceramics or in clinker, special attention has been paid to the effect of the wastes on the quality of gaseous emissions during the process. As a matter of fact, the criteria used for the acceptance of the incorporation process for each residue, was also based on the verification of compliance of the gaseous emissions chemical compositions with applied environmental regulations.

Some wastes contain appreciable amounts of metallic values. That makes them good candidates as ores for metals recovery, by extraction metallurgy routes. Work is being done on the recovery of nickel and copper from galvanic sludges (7), on the extraction of zinc and lead from electric arc furnace dusts and on the recovery of metals from liquid effluents by selective organic solvents.

In this field, special attention is being devoted to the recovery of copper and nickel from galvanic sludges, by hydrometallurgical routes. In this case, research is being done on laboratory scale, to determine differential precipitation of compounds from metal containing leachates and selective extraction of metals by specific organic solvents (project Valmetais, with the participation of one Portuguese company). The extraction of zinc and lead from electric arc furnace steelmaking dusts has been studied by a mixed acetic/sulphuric process. High level of recovery for lead, and for zinc, when this metal is present in the form of zincite (8-9), has been obtained.

Recovery of contained energy from wastes is being studied especially on polymers, biomass and textiles. Routes include pyrolytic decomposition and gasification operations, to produce valuable synthetic gases. Also, application of plasma assisted processes to some special cases is being evaluated.

In the field of waste-to-energy, research is being done, at this moment, on the treatment of chloride containing polymers, like PVC. The study aims the recovery of chlorine as valuable products, and the energy production from the chlorine-free plastic. This latter phase is being studied by pyrolytic decomposition, the quality of the gases being evaluated, in view of its uses. An overall process is to be proposed, with the aim of demonstrating it at pilot plant scale.

Valuable organic materials may be recovered from animal by-products. Egg shells recovery for making de-pollution adsorbents and fat processing by transesterification are being studied.

Employment of construction and demolition recyclables in road and pavement fabrication, as well as in cement mortars, is also a matter of research at this moment at CVR. Also, employment of steelmaking slag, from electric arc furnace process, as road base material, is being tested (10), in laboratory as well as in experimental field road, in this latter case the effect on environment (groundwater contamination) being also determined.

Production of RDF (residue derived fuels) from mixed plastics and textiles, as well as biodiesel production from animal fats is being studied, to produce fuels from these materials. In what concerns the production of RDF, incorporation of with pellets with plastics, textiles or leather wastes, has been studied. In this case, mechanical performance and durability of pellets, as well as heat content, were evaluated. Also, quality of gaseous emissions during burning of wood pellets has been determined, in order to assure non-polluting employment of this derived fuel, and to define eventual limitations to its use. This has been done in a first approach under laboratory conditions, with a combustion testing facility, and, latter on, in a pellet producing company. Results allowed define specific conditions for several residues (11), rendering an innovative waste management approach for these types of residues.

For each concrete situation, CVR evaluates the possibility of developing specific waste management options. In that case, processes are always designed to introduce the concept of looking to wastes as valuable resources that society needs to preserve.

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